THIS LAND IS PURE LAND: HOW BARRIERS TO PROPERTY DEVELOPMENT AFFECT THE VALUE OF STATE-LEVEL RENEWABLE ENERGY INCENTIVE PROGRAMS

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ABSTRACT

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Title: This Land Is Pure Land: How Barriers to Property Development Affect the Value of State-Level Renewable Energy Incentive Programs

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Why is it that states like California and New York, which have some of the strongest environmental regulations and renewable energy incentive programs in the country, have had less success incorporating clean power onto the grid than their relatively laissez-faire counterparts like Texas and Iowa? Using a combination of econometric analysis and case studies into the development process, this thesis evaluates how land use regulations influence the renewable energy industry – and, consequently, how to maximize the economic value of state-level incentives.

The project is divided into three sections. The first provides an overview and history of how the nature of the renewable energy industry came to vary so much from state to state. In particular, it explores the difference between regulated and deregulated electricity markets, as well as the emerging rift between distributed renewable power (user-level; for example, rooftop solar panels) and utility-scale renewable installations (think solar farms). The second section describes the econometric component of the thesis, which evaluates which characteristics of land development – including the presence of endangered species, average land value, and quantity of government-owned property – have the greatest impact on project development, as well as which states' renewable incentive programs are helped and hurt the most by these underlying qualities. The third section discusses the policy implications of the study, offering recommendations for how states can improve their incentives and touching on how federal interventions and technological advancements can change the conversation moving forward.

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To Mom and Aba, for answering my phone calls.

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Chapter I: Yesterday

An introduction to the history of renewable energy markets in the U.S. and an overview of where the wind and solar industries stand today

Section A: Overview and methodology

The windswept plains of Texas and Iowa are dotted with spinning turbines that harness the energy of powerful gusts into usable electricity. But driving through other portions of the Midwest, or the blustery Rocky Mountains, you would be hard-pressed to spot any propeller blades whirring over the horizon — untold millions of dollars in value literally vanishing into thin air. In September 2016, Texas and Iowa generated more wind power than any other states in the country, with Texan turbines providing 3,923 megawatt-hours of electricity and Iowa's producing 1,552. Meanwhile, Iowa's neighbor Missouri generated just 87 MWh of wind power during the same period, and Wyoming — which has one of the highest potential wind capacities in the country — produced 277.[1]

In the same vein, the dry hills of Southern California are covered in solar panels, powering millions of the state's homes and factories with the energy of its year-round sunshine. And yet Arizona, just one state over and renowned for its blistering deserts, produced over twenty times as much power from natural gas and coal than from solar photovoltaics in August 2016.[2]

The lesson here is that, like so much else about its history and culture, America's energy landscape is messy, nonuniform, and often illogical. That is because it is shaped not within the halls of the U.S. Congress or the Environmental Protection Agency, but rather by policies and

[1] "Electric Power Monthly with Data for September 2016." U.S. Energy Information Administration, November 2016. Table 1.14-A.
[2] "Arizona State Profile and Energy Estimate." U.S. Energy Information Administration, October 2016.

regulations established at the state and regional level. But the effect of these disparate regulatory climates goes further than determining whether or not renewable energy installations are developed in a specific part of the country. They also impact the magnitude of renewable grid penetration — in other words, what percentage of a state's electric grid can be feasibly powered by renewable resources, and how close the state comes to reaching that theoretical limit. They determine whether renewable projects are developed on a distributed, or user-level, scale — rooftop solar panels, for example — or in the form of large solar and wind farms. And they influence the local cost of power, which is a large determinant of which resources supply that power.

While a number of analyses have sought to evaluate the effectiveness of particular statewide policies in boosting overall renewable penetration, there have been few attempts to compare which elements of the project development process have the greatest influence on whether or not an ostensibly pro-renewables policy works as designed. In light of this research gap, this paper evaluates how different barriers to property development affect the value of state-level renewable incentive programs. There are two primary components to the project. The first component uses econometric analyses to evaluate how various property characteristics affect both the scale and nature of renewable deployment in each of the fifty states, including environmental, economic, and political variables. The second component consists of case studies into the project development process, built through numerous interviews with developers, financiers, and policymakers. Unlike the econometric project, the case studies focus on four impactful state-level policy areas within a few different U.S. independent system operator (ISO) regions with unusually high renewable penetration — most notably Texas and California.

I chose these locations because Texas has one of the most deregulated electricity markets in the country and a high penetration of utility-scale renewable power, whereas California has deployed a number of policy mechanisms and regulations that incentivize renewable deployment and distributed generation in particular. Thus, while the electric grids of both states have integrated more renewable power than anywhere else in the country, they have created vastly divergent business climates for developers and regulators to navigate, according to several developers and financiers interviewed for this project. Texas and California are also two of the only states whose energy markets are regulated and managed by their own independent system operators: respectively, the Electric Reliability Council of Texas (ERCOT) and California Independent System Operator (CAISO).

For simplicity, I have divided each of the regulatory structures this thesis evaluates into four subcategories:

Transmission infrastructure

There are three power grids that distribute electricity in the United States. The Eastern and Western Interconnections span the regions opposite each side of the Rocky Mountains, and the ERCOT Interconnection supplies power for most of Texas (Fig. 1).[3]

[3] Figure 1 source: Electric Reliability Council of Texas.

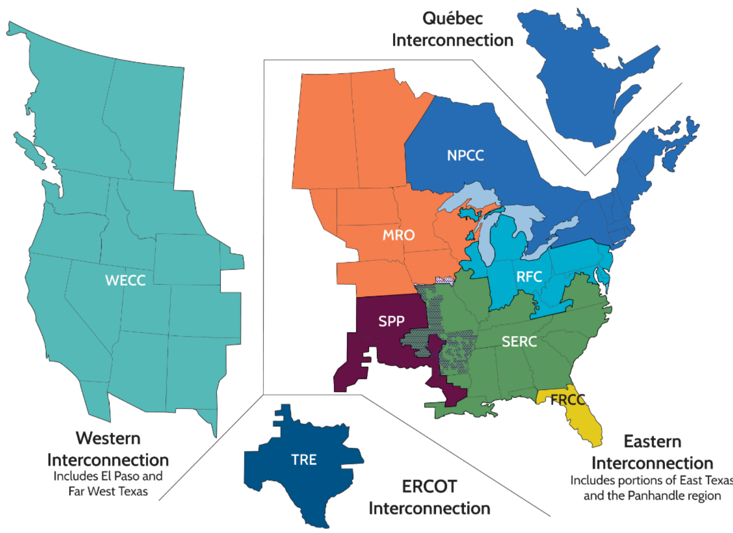

Figure 1

These grids are further subdivided into ISO regions, which are responsible for regulating the purchase, sale, and distribution of electricity in accordance with local laws, as well as for managing the day-to-day operations of the grid.[4]

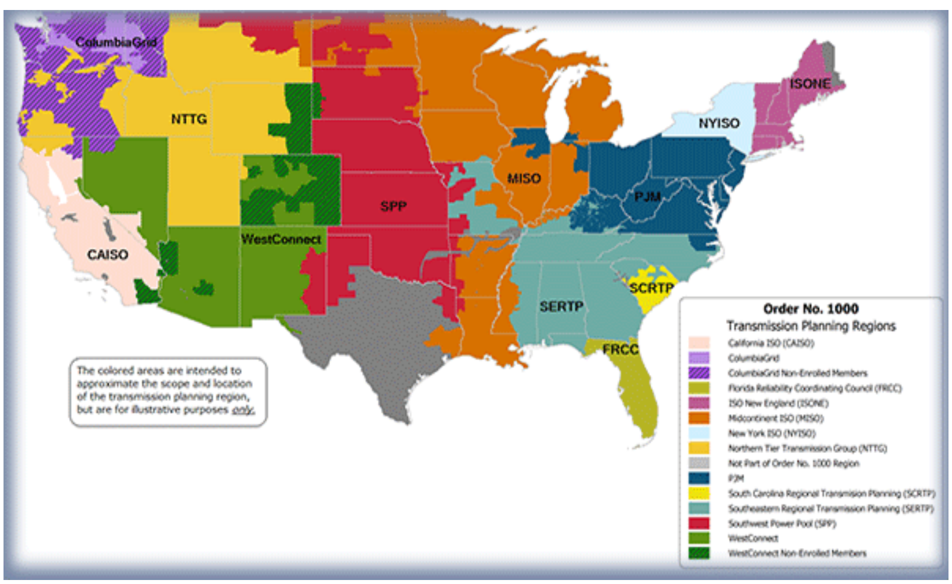

Figure 2

[4] Figure 2 source: Federal Energy Regulatory Commission.

It is these ISOs that are responsible for strategically deploying power lines so as to maintain widespread access to electricity while keeping costs under control. In essence, this mission is comprised of two responsibilities: transmission, which uses high-voltage power lines to transport electricity from generation facilities to load centers; and distribution, which uses low-voltage lines to distribute that power to consumers.[5]

Because utility-scale wind and solar power are often sited far from load centers, systems with well-developed transmission networks are better equipped to integrate those resources into the grid at large. As such, the transmission networks most amenable to utility-scale renewables have (a) installed high-voltage lines capable of efficiently transmitting a large capacity of power, and (b) strategically located those lines so as to connect regions with strong wind and solar resources to major load centers. ERCOT is a paragon in this respect. In 2013, the organization completed a $7 billion network of 345 kilovolt direct-current lines[6] running from remote areas like the Panhandle and West Texas, referred to as Competitive Renewable Energy Zones (CREZ), towards the state's major cities.[7] Since then, Texas's wind power generation has increased by 60.43 percent relative to the 2013 baseline,[8] despite concerns that the CREZ lines are already becoming congested due to the abundance of wind power developed in the region.[9]

Distributed power, in contrast, is generated at a small scale and on an individual user level. As a result, systems that handle distributed power well are those with modern distribution networks, which include innovations like load-shifting incentives and demand response programs that help utilities manage their load more efficiently. While this paper does not discuss

[5] Andrade, Juan, Baldick, Ross, "Estimation of Transmission Costs for New Generation," White Paper UTEI/2016-09-1, 2016, available at http://energy.utexas. edu/the-full-cost-of-electricity-fce/.
[6] For the sake of comparison, the typical alternating-current power line carries 69 kV of electric potential
[7] "Competitive Renewable Energy Zones (CREZ) Maps." Public Utility Commission of Texas. Docket No. 35665, Attachment A.
[8] Energy Information Administration
[9] Martin, Richard. "In Texas Oil Country, Wind Is Straining the Grid." *MIT Technology Review*, 6 August 2016.

methods of maximizing distributed renewable power, it does describe why states that have difficulty incentivizing utility-scale renewables often have a higher concentration of distributed resources.

Land management

Wind farms and utility-scale solar installations are land-intensive systems.[10] As such, the costs of procuring property and obtaining all necessary building permits, as well as the time-cost of development, play an enormous role in determining whether a region is amenable to large renewable power generation facilities. While states can exert some degree of control over the permitting process and municipal governments are primarily responsible for zoning laws, there are two important market characteristics within the land management category that fall under federal jurisdiction. Firstly, property owned by the federal government and overseen by Bureau of Land Management is governed under different regulations than private or state-owned land. Secondly, the Endangered Species Act – and its state-level equivalents, like the notorious California Environmental Quality Act (CEQA) – can preempt project development even on private property, which is part of the reason why building solar installations is easier even in relatively resource-poor East Texas than in California's Mojave Desert.[11] Chapter 2 goes into more detail on how different designations of land protection affect the development process.

Taxes and incentives

This subcategory includes both demand-side mechanisms, such as tax cuts and cash payouts to homeowners who choose to install solar panels, and supply-side mechanisms, like production and investment tax credits for companies that develop utility-scale renewable installations. It excludes the federal versions of the production and investment tax credits as well

[10] Denholm, Paul, et al. "Land Use Requirements of Modern Wind Power Plants in the United States." National Renewable Energy Laboratory, Technical Report, NREL/TP-6A2-45834, August 2009.
[11] Badichek, Gregg. "Resolving Conflicts Between Endangered Species Conservation and Renewable Energy Siting: Wiggle Room for Renewables?" Consilience: *The Journal of Sustainable Development*, Vol. 14, No. 2, 2015.

as Department of Energy-funded subsidies like the Advanced Research Projects Agency — Energy (ARPA-E), because those mechanisms are independent of state-level regulation. Because there is no consistent metric quantifying the value of these tax and incentive programs, this analysis uses an aggregation of state rankings compiled by trade associations and consultancies as a stand-in for the strength of a state's renewable financing mechanisms.

Electricity market design

Unlike the previous three subcategories, electricity markets are not regulated by the states themselves. Instead, electricity markets are managed and operated by ISOs, which are nongovernmental organizations overseen by the Federal Energy Regulatory Commission (FERC), with the exception of the wholly independent ERCOT. Because this paper's emphasis lies on state-level policy initiatives, its analysis of ISO guidelines primarily focuses on decoupling and transmission buildout, which are the regulatory spaces under ISO jurisdiction over which states exert the greatest degree of control.

Decoupling refers to the disaggregation of power generation, transmission, and distribution that began in the 1980s.[12] Before that time, electricity markets in the U.S. were vertically integrated, with a single firm responsible for owning and operating power plants, transmitting that power into population centers, distributing it to consumers, and servicing the grid to prevent blackouts and disruptions. That business structure emerged around the turn of the 20th century, when the federal government concluded that electric utilities, like telegraph lines and railroads, were "natural monopolies," meaning that the public would be better served with a single company controlling every aspect of the electricity industry because of its high infrastructural barriers to entry. The theory was codified into law in the form of Public Utility

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[12] Tuttle, David P., Gülen, Gürcan, Hebner, Robert, King, Carey W., Spence, David B., Andrade, Juan, Wible, Jason A., Baldick, Ross, Duncan, Roger, "The History and Evolution of the U.S. Electricity Industry," White Paper UTEI/2016-05-2, 2016, available at http://energy.utexas.edu/ the-full-cost-of-electricity-fce/. 2.

Holding Company Act in 1935, which ensured that utilities had monopoly control over their regions of operation.[13] In exchange for their government-guaranteed control of the market, utilities had to relinquish the power to set power prices to local public utility commissions and ISOs, and they were heavily incentivized to build as much capacity as possible to bring electricity to those who lacked it.[14]

But in the 1970s, the public benefit of the natural monopoly began to decline. Most of the country had already been electrified, but the demand for power was still increasing, which encouraged utilities to commission bigger and more expensive power plants. Around the same time, the Organization of Petroleum-Exporting Countries (OPEC) oil embargoes and Three Mile Island meltdown, both discussed later in this chapter, pushed utilities to shift away from petroleum and nuclear fuel as electricity-generating resources and invest in energy technologies with smaller generating capacities like hydropower and natural gas.[15] As a result of these shifts in the market, the need for power providers to own generation facilities declined. In response, Congress passed the Public Utility Regulatory Policies Act (PURPA) in 1978, which paved the way for states to deregulate the utility industry through the 1980s and 1990s. The decoupling wave began in states that stood the most to gain from instituting a competitive market for power generation: those with high power prices or a strong resource base for natural gas or renewables (Fig. 3).[16] However, a number of states that fit that description — most notably California — suspended the deregulation process following the Enron scandal in 2001, discussed in further detail in Chapter 2.

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[13] Tuttle 5.
[14] Kihm, Steve, et al. "You Get What You Pay For: Moving Toward Value in Utility Compensation, Part 1 – Revenue and Profit." *America's Power Plan*, June 2015.
[15] Tuttle 8.
[16] Figure 3 source: U.S. Energy Information Administration

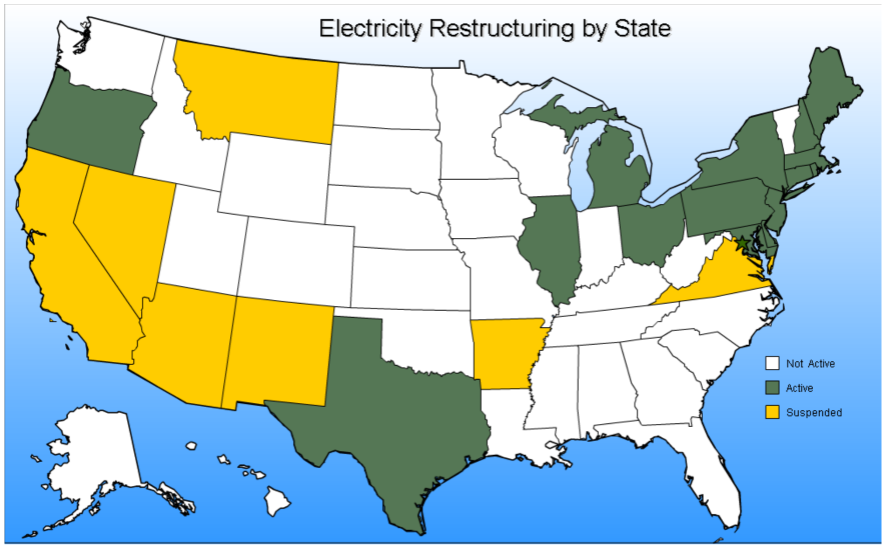

Figure 3

In addition to decoupling, the analysis of market mechanisms will include a discussion of market factors that influence which resources are able to generate the cheapest electricity in a given region. For example, capacity markets, which incentivize plants that can theoretically provide large quantities of power, and ramping markets, which incentivize plants that can quickly change their power output, can be used to subsidize the types of natural gas plants needed to ameliorate the effects of wind and solar variability.

Section conclusion

This method of evaluation leads to a conclusion that evaluates whether certain policies or combinations thereof could benefit less developed renewable energy markets throughout the country, as well as which policies or policy combinations are region-specific and likely not replicable. An example of the former case, discussed further in Chapter 2, is Texas's combination of lax permitting regulations and lack of a capacity market, which can reduce power prices and facilitate renewable development in any state with a low population density and strong solar and wind resources. An example of the latter case, also discussed in Chapter 2, is California's relative lack of investment in transmission. While CAISO has lobbied for the creation of an integrated Western grid, its sparse intrastate HVDC infrastructure has not hindered renewable deployment as it might elsewhere. The two primary causes underlying that anomaly are somewhat unique to California: firstly, the proximity of the state's power-generating regions to the population centers where that power is consumed reduces the need for high-voltage transmission; secondly, project development in California faces so many regulatory and environmental hurdles that the ISO's impact on renewable penetration is limited.

Section B: Overview of U.S. wind and solar industry

Historical Roots

The explosive growth of America's wind and solar industry is a relatively recent phenomenon. At the beginning of the century, the U.S. had only 2,539 MW of wind capacity and 138.8 MW of solar capacity installed[17] – combining to generate just 0.13 percent of America's electricity.[18] By 2016, those numbers had grown to 82,171 MW of wind and 35,800 MW of solar, enough to supply 6.9 percent of the nation's power needs (Fig. 4).[19] [20] The majority of this rapid development is market-driven, with the cost of wind and solar inputs declining rapidly while the price of operating coal and nuclear plants rises. But it took a series of policy initiatives beginning in the 1970s to lay the groundwork for the renewables market to emerge in the first place.

[17] See citation for Figure 4
[18] "Electric Power Monthly, March 2001." U.S. Energy Information Administration. 9.
[19] "Electric Power Monthly, February 2017." U.S. Energy Information Administration.
[20] Figure 4 source: Wind: "Installed Wind Capacity." WINDExchange, Office of Energy Efficiency and Renewable Energy, U.S. Department of Energy. Solar: Compiled via U.S. Solar Market Insight reports, Solar Energy Industries Association.

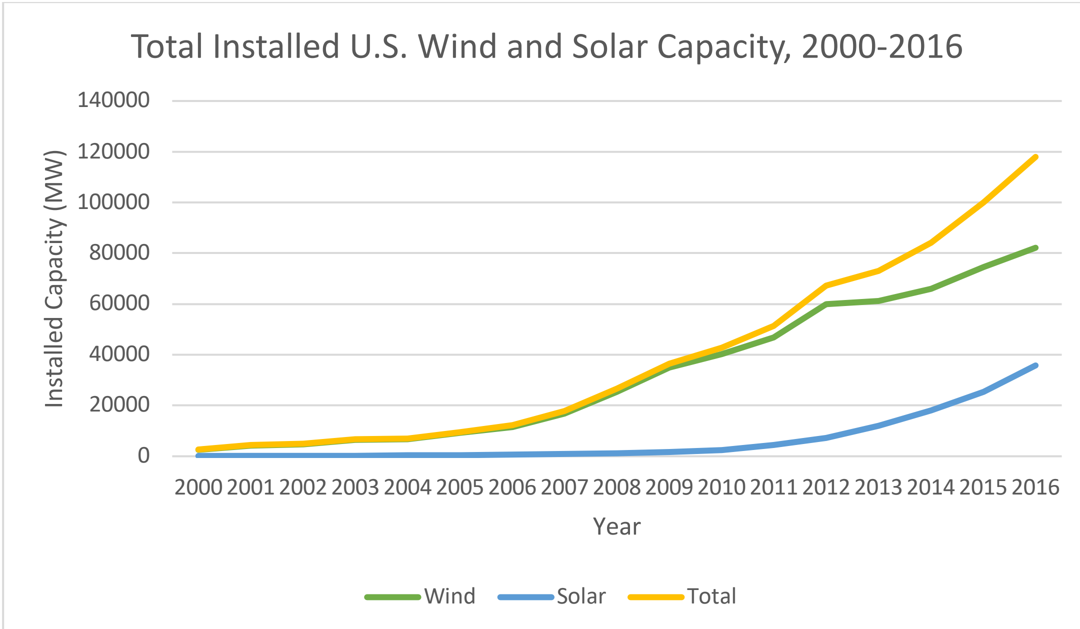

Figure 4

In 1973, the Organization of Petroleum Exporting Countries (OPEC) caused a pandemonium in the U.S. economy that would shape American energy policy for decades to come. In response to American support for Israel during that year's Yom Kippur War, OPEC embargoed its oil exports to the U.S., cutting off 35 percent of the nation's petroleum supply.[21] The embargo is largely remembered for its effects at the gas pump, which inspired new fuel-efficiency standards for vehicles and created a political impetus to find oil from non-OPEC sources.[22] But its aftermath also brought seismic changes to America's electricity sector, which at the time derived nearly 20 percent of its power from petroleum — compared to less than one percent today.[23] [24] In anticipation of future supply disruptions from OPEC, as well as projected

[21] Lovins, Amory. "What Did the 1973 Oil Embargo Teach Us?" *RMI Outlet*, Rocky Mountain Institute. 17 October 2013.
[22] Ibid.
[23] Logan, Jeffrey. "U.S. Power Sector Undergoes Dramatic Shift in Generation Mix." Renewable Energy Project Finance, National Renewable Energy Laboratory. 26 February 2013.
[24] Muyskens, John, et al. "Mapping how the United States generates its electricity." *Washington Post,* 29 March 2017.

increases in demand stemming from population growth, Congress took steps to allow electric utilities to procure alternative sources of power, culminating in the passage of PURPA in 1978.[25]

It was in this climate that physicist Amory Lovins popularized the concept of a "soft path" energy strategy, which emphasized "a rapid development of renewable energy sources matched in scale and in energy quality to end-use needs."[26] Lovins viewed centralized power generation as financially wasteful and energy-inefficient, and he subscribed to the now-quaint ideas that fossil energy reserves were quickly depleting and that the expansion of nuclear power would lead to nuclear arms proliferation.[27] But his perspective's publication by *Foreign Affairs*, an imprint of the Council on Foreign Relations, allowed for the idea of widespread deployment of wind and solar power to enter America's political zeitgeist for the first time.

Two years after PURPA was signed into law, Congress established the first federal renewable energy incentives under Title IV of the Energy Security Act, which established an investment program for solar developments as well as a pilot program to encourage states to develop pro-renewables programs of their own.[28] In 1983, that state-level initiative culminated in Iowa's passage of nation's first renewable portfolio standard, which required its two investor-owned utilities to commission a total of 105 MW of electricity from renewable sources beginning that same year.[29] While development did not increase much beyond the proof-of-concept stage through the rest of the decade, interest in solar and wind power increased again in the 1990s amid growing awareness of climate change, pollution, and the depletion of the ozone

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[25] Tuttle 7.
[26] Lovins, Amory. "Energy Strategy: The Road Not Taken?" *Foreign Affairs*, October 1976.
[27] In 1982, Lovins cofounded the Rocky Mountain Institute, which is now one of America's preeminent environmental think tanks.
[28] *Energy Security Act*, S.932, 96th U.S. Congress, 1979-80 sess.
[29] *Alternative Energy Law of 1983*, S.F. 380, 70th Iowa General Assembly, 1983 sess.

layer.[30] In 1994, Minnesota adopted America's second RPS, which required Xcel Energy to commission 225 MW of wind power by 1998.[31] By 2000, nine other states had followed suit; today, 29 states and Washington, DC have renewable portfolio standards.[32]

On the federal level, the Energy Policy Act of 1992 continued PURPA's effort to separate power generation from transmission by requiring utilities to transport third-party power over their own lines, which allowed facilities smaller than utility-owned coal or nuclear plants to access a consumer base.[33] The law also increased federal subsidies for renewable technologies, and its 2005 update established two separate tax credits for wind and solar developers: an investment tax credit, which incentivizes financiers to invest in costly projects, and a production tax credit that scales with the total output of a renewable energy facility.[34] The PTC and ITC have since been extended several times, most recently in 2015.

Recent price trends for power generating resources

These mandates and incentives, coupled with the continuing restructuring of the electricity industry, helped provide the nascent wind and solar industries with a means by which to enter the marketplace. But it took three paradigm shifts, each of which has taken place within the past ten years, to enable those resources to become price-competitive with fossil fuels. The earliest of these paradigm shifts is the boom in shale gas extraction that took place in the late 2000s, when advancements in horizontal drilling and hydraulic fracturing created extraction opportunities in previously inaccessible natural gas deposits. From 2005 through 2011, U.S. gas

[30] Joskow, Paul. "U.S. Energy Policy During the 1990s." National Bureau of Economic Research, Working Paper No. 8454. September 2001.
[31] "Xcel Energy Wind and Biomass Generation Mandate." *DSIRE*, NC Clean Energy Technology Center. Database entry summarizes Minn. Stat. § 216B.2424.
[32] Barbose, Galen. "Renewable Portfolio Standards in the United States: A Status Update." 2012 National Summit on RPS, Washington, DC, 3 December 2012.
[33] Tuttle 8.
[34] Goodward, Jenna and Mariana Gonzalez. "Bottom Line on Renewable Energy Tax Credits." *World Resources Institute*. October 2010.

production increased by 27 percent, and the share of the overall U.S. gas market supplied via shale reserves increased from 4 percent to 30 percent.[35] Due to this dramatic increase in production, the spot price of natural gas futures dropped from a peak of $8.86 per million Btu in 2008 to $2.62 per million Btu in 2014.[36] At that price point, natural gas is the cheapest available fuel for electricity generation, which explains why it now generates more of America's power than any other resource.

The coal industry, which had fueled at least a plurality of America's power plants through the 20th century, struggled to compete with this price decline. In addition to the increased price competition from natural gas, coal suppliers have had to grapple with tightening environmental regulations pertaining to the quantity of toxic trace elements released during the combustion process, most notably a 2011 EPA ordinance that lowered the maximum allowable level of mercury emissions from coal-fired power plants.[37] Those two factors have placed coal producers in an economic quandary: the price they would need to charge to turn a profit in the face of increasing operating costs is higher than the retail price of natural gas throughout most of the country.[38] As a result, U.S. coal production dropped 10.3 percent between 2014 and 2015, and coal's share of the power sector declined from 39 percent to 33 percent over the same time period.[39] The coal industry also faced pressure from the Clean Power Plan, a 2015 executive order issued by Barack Obama that mandated a 32 percent reduction in carbon emissions from electricity generation by 2040. But the decline of the coal industry is likely to continue even after

[35] Krupnick, Alan, et al. "Sector Effects of the Shale Gas Revolution in the United States." *Resources for the Future*, July 2013.
[36] "Henry Hub Natural Gas Spot Price." U.S. Energy Information Administration.
[37] "National Emission Standards for Hazardous Air Pollutants From Coal and Oil-Fired Electric Utility Steam Generating Units and Standards of Performance for Fossil-Fuel-Fired Electric Utility, Industrial-Commercial Institutional, and Small Industrial Commercial-Institutional Steam Generating Units." 40 Fed. Reg. 60 & 63, Vol. 77, No. 32. 16 February 2012.
[38] *The Full Cost of Electricity.* UT Energy Institute, The University of Texas at Austin.
[39] *2015 Annual Coal Report*, U.S. Energy Information Administration. 3 November 2016.

President Donald Trump's rescission of the CPP in March 2017. According to a survey of utilities conducted by Utility Dive after the 2016 presidential election, 79 percent of utilities project their use of coal to decline over the next ten years, with 52 percent projecting a significant decline.[40]

While natural gas began to displace coal as America's primary source of nonrenewable power, the prices of solar and wind inputs dropped precipitously (Figs. 5 & 6).[41] [42] For the wind industry, this drop largely stemmed from technological advancements that allowed developers to build taller turbines, which can harness stronger gusts and generate electricity more efficiently than their shorter counterparts.[43] In the photovoltaic solar industry, prices began to fall when Chinese manufacturers bolstered by government subsidies entered the market in the mid-2000s, according to Dan Reicher and Jeffrey Ball of the Steyer-Taylor Institute for Energy Finance at Stanford University.[44] With construction and labor costs lower than in the United States, China accounts for over 70 percent of the global supply of crystalline silicon solar panels. These catalysts set off a series of positive feedback loops within the wind and solar industries: after becoming cost-competitive enough to bid into competitive power markets, firms developed the institutional knowledge and economies of scale to work towards reducing labor and development costs. And private and federal research helped suppliers continually improve the capacity factors of their equipment – in other words, the percentage of installed capacity that ultimately reaches the grid.

[40] "2017 State of the Electric Utility Survey." *Utility Dive*. March 2017

[41] Naam, Ramez. "Smaller, cheaper, faster: Does Moore's law apply to solar cells?" *Scientific American*, 16 March 2011.

[42] Hunt, Tam. "Guest Post: The True Cost of Renewable Energy – Reality vs. the LA Times." *Greentech Media*, 26 September 2012.

[43] Wiser, Ryan and Mark Bolinger. "2015 Wind Technologies Market Report." Lawrence Berkeley National Laboratory, U.S. Department of Energy. August 2016.

[44] Ball, Jefferey and Dan Reicher. "Making Solar Big Enough to Matter." *New York Times*, 21 March 2017.

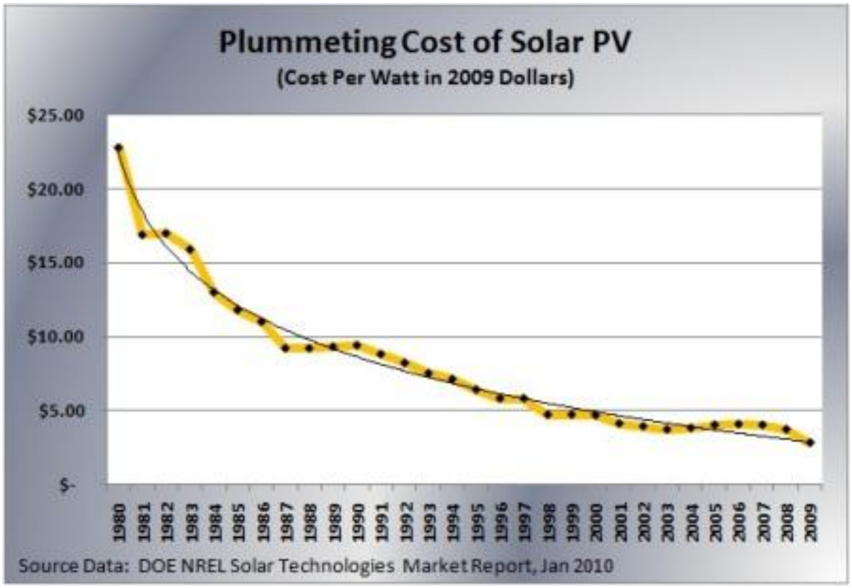

Figure 5

Figure 2. *Long-term price trend for solar and wind (source: UN IPCC).*

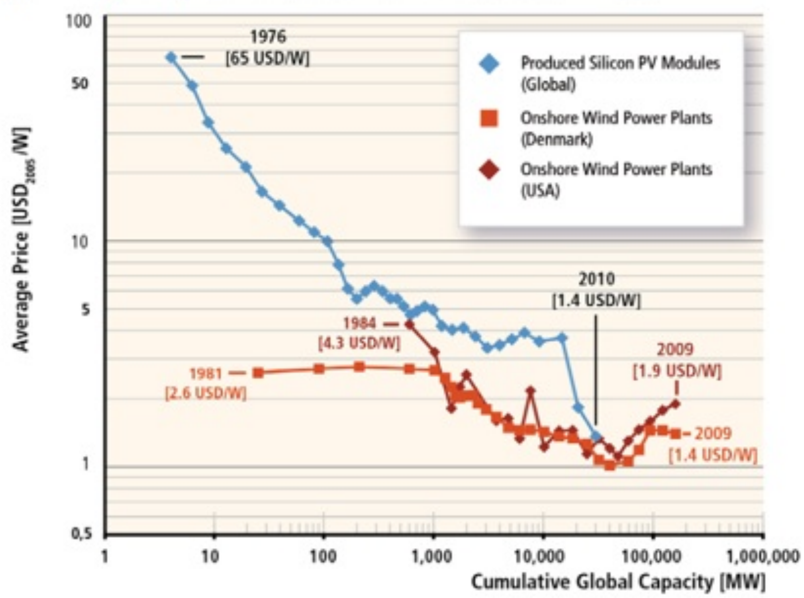

Figure 6

As a result, those downward price trends should continue in the years ahead. GTM Research, a leading market research firm in the energy sector, projects the price of solar inputs to fall below $1.00 per watt by 2020, which would help utility-scale solar compete with natural gas even outside of the sunniest markets.[45] Meanwhile, a 2016 expert elicitation study on wind power reported an overwhelming consensus that prices will continue to decline through at least the intermediate future (Fig. 7).[46] [47] Neither projection takes into account the possibility of technological advancement, discussed further in Chapter 3.

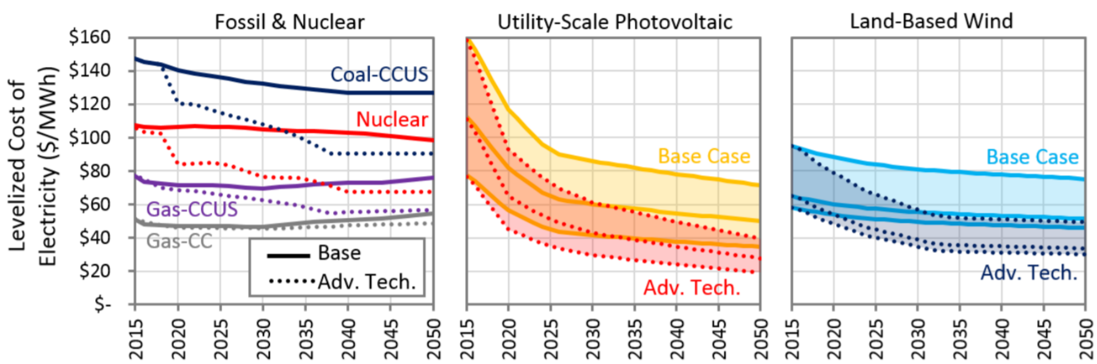

Figure 7

However, while declining input prices will help catalyze project development in an array of different markets, the extent to which America's power grids boost their uptake of wind and solar power going forward largely relies on whether they are designed to integrate those resources. Unlike natural gas, coal, or nuclear power, wind and solar carry a degree of weather-based variability that can threaten the stability of an electric grid ill-equipped to accommodate it. Complicating matters further, the flexibility with which renewables can be deployed – solar installations can range in size from a single unit on a roof or streetlight to a miles-long array of panels – has a profound influence on demand patterns in America's power sector.

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[45] Gallagher, Ben. "U.S. Solar PV Price Brief H1 2016: System Pricing, Breakdowns and Forecasts." *GTM Research,* June 2016.
[46] Wiser, Ryan, et al. "Expert elicitation survey on future wind energy costs." Nature Energy. September 2016.
[47] Fig. 7 source: Donohoo-Vallett, Paul, et al. "Impact of Clean Energy R&D on the U.S. Power Sector." National Renewable Energy Laboratory, Technical Report NREL/TP-6A20-67691, January 2017.

California's power market is a cautionary tale in how these emerging technologies can cause disruptions in the power sector. Because of its strong solar resource and the high population density of its urban areas, California has the highest annual generation potential for rooftop solar power of any state – theoretically, distributed solar can supply 43.6 percent of the state's power needs.[48] Accordingly, the state's power grid must accommodate over 3,000 MW of residential solar, representing 32 percent of its total installed solar capacity as of 2015.[49] On sunny midafternoons, that quantity of power creates a massive decline in the amount of power consumers demand from utilities, which in turn makes it difficult for natural gas plants or utility-scale solar facilities to operate at a profit and often requires them to temporarily shut down to avoid oversupply. However, once the sun sets, the utility's demand function ramps up quickly, which poses a challenge to the natural gas and coal plants that supply most of the state's power after dark (Fig. 8).[50] It also requires the state to curtail solar generation during periods of oversupply, which deflates their economic value – no power plant, solar or otherwise, can generate revenue while idle. In February 2017, CAISO issued a memorandum to its board of governors warning of the possibility of up to 8 GW of solar curtailment that spring.[51]

Section conclusion

Despite decades of policy incentives designed to create opportunities for renewable technologies to penetrate the electricity market, it took a recent series of cost declines, motivated by rapidly falling input and manufacturing costs, for wind and solar generation to compete with cheap natural gas as a major source of new power generation. Going forward, market design and

[48] Gagnon, Pieter, et al. "Rooftop Solar Photovoltaic Technical Potential in the United States: A Detailed Assessment." *National Renewable Energy Laboratory*, Technical Report NREL/TP-6A20-65298. January 2016. 26.
[49] Comstock, Owen. "California has nearly half of the nation's solar electricity generating capacity." *Today in Energy*, U.S. Energy Information Administration. 5 February 2016.
[50] Figure 8 source: "What the duck curve tells us about managing a green grid." California Independent System Operator, 2016.
[51] Berberich, Steve. "Memorandum to ISO Board of Governors." California Independent System Operator, 9 February 2017.

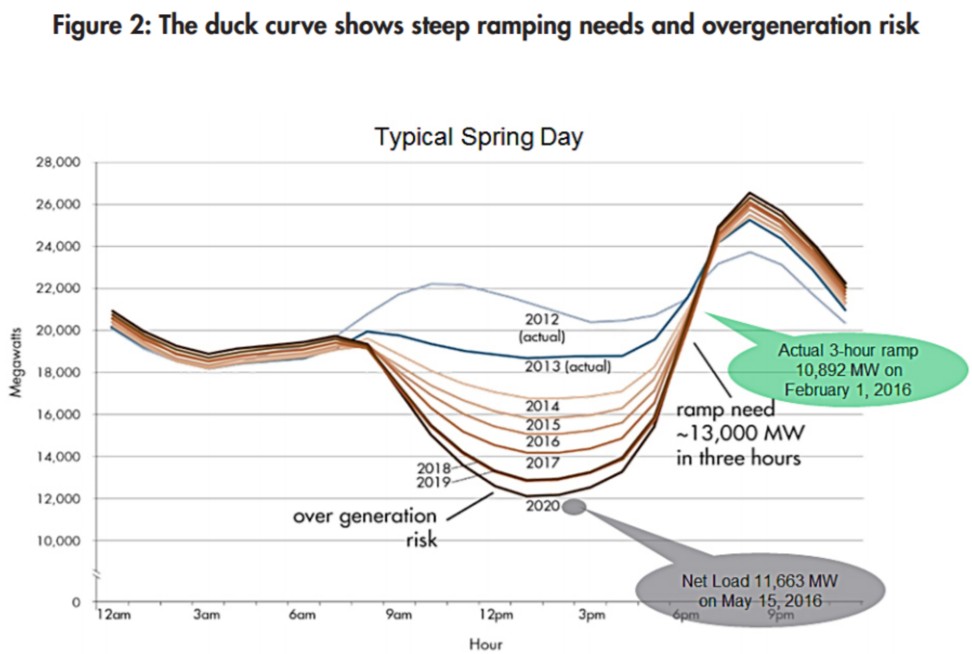

Figure 8

grid infrastructure will become an increasingly strong indicator of how much renewable power a state or region can successfully develop. But for the time being, there is room for continued growth and development, particularly in markets with a strong resource base or high enough power prices to create a competitive market. The next chapter will evaluate what barriers exist to development today and how they influence a state's ability to build out its renewable infrastructure.

Chapter II: Today

An empirical analysis of how state-level market characteristics affect renewable development

Section A: Prior Literature

Overall, the evidence that policy mechanisms positively affect renewable uptake is mixed. A 2009 study into renewable portfolio standards concluded that, all else held constant, RPS had no statistically significant effect on the percentage of renewables in a state's power mix, although states with RPS tended to generate more renewable power in total than those without.[52]

There is similar debate as to whether restructuring in electricity markets has promoted or discouraged renewable integration. From an empirical standpoint, there is no conclusive evidence suggesting that whether a state's power market is deregulated affects its deployment of renewables.[53] From a theoretical standpoint, there are compelling arguments in either direction. Utilities in deregulated markets face greater pressure to procure the most cost-effective generation sources possible, which could preclude them from incentivizing or accommodating solar power and incentivize them to lobby against favorable renewable policies at the state level.[54] However, investor-owned utilities in regulated markets are often compensated based on how much generating capacity they develop, a holdover provision of an era when rapidly constructing massive centralized power plants was the only way a utility could adequately electrify a region.[55] That regulatory structure gives utilities in regulated markets a disincentive

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[52] Carley, Sanya. "State renewable energy electricity policies: An empirical evaluation of effectiveness." *Energy Policy*, Vol. 37, May 2009.
[53] Kim, Sung Eun, et al. "Does Power Sector Deregulation Promote or Discourage Renewable Energy Policy? Evidence from the States, 1991-2012. *Review of Policy Research*, Vol. 33, Issue 1. January 2016. 22-50.
[54] Heiman, Mark and Barry Solomon. "Power to the People: Electric Utility Restructuring and the Commitment to Renewable Energy." *Annals of the Association of American Geographers,* Vol. 94, Issue 1. 94-116.
[55] Aas, Dan and Michael O'Boyle. "You Get What You Pay For: Moving Toward Value in Utility Compensation, Part 2 – Regulatory Alternatives." *America's Power Plan*, June 2016.

against investing in distributed resources or renewables, which typically have a lower nameplate capacity than coal, nuclear, or baseload gas plants.

Previous studies have also found that tax incentives are, according to an overview by Sanya Carley and Tyler Browne, "best and most often used in a supporting or complementary role to other policy instruments."[56] In particular, tax incentives can "effectively promote the development of small-scale renewable installations…at the state level," while providing less value to utility-scale installments.

There are two main contrasts between this model and those of previous studies. Firstly, this model includes variables that evaluate the effects of barriers to property development, particularly permitting restrictions surrounding federal and protected land as well as the Endangered Species Act and National Environmental Policy Act. A few other studies have accounted for a state's predilection towards environmental protection using variables like Sierra Club membership, which might account for local enthusiasm towards preservationist causes but, as discussed below, does not encompass the full impact of environmental statutes. There have also been studies that describe how the environmental review process hinders power plant development in California specifically, although none that focus on renewables in particular. A report by the Bay Area Economic Forum in 2001 found that while the state's byzantine regulations delayed new capacity additions, they "do not appear to have been a critical impediment to investment."[57] Secondly, this model divides utility-scale and distributed solar generation, allowing for an evaluation of whether certain policy categories have a greater impact

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[56] Carley, Sanya and Tyler R. Browne. "Innovative US energy policy: a review of states' policy experiences." *WIREs Energy Environ* 2013, Issue 2. 488-506.

[57] Bay Area Economic Forum, *The Bay Area – A Knowledge Economy Needs Power,* San Francisco, California. 2001.

on one sector of the solar industry or the other. Finally, the model uses many of the same regressors as previous studies, updated to include state-level power generation data from 2016.

In order to develop the model, I constructed a database with information on a state's generating capacity for wind and solar power as well as for conventional resources. The database also includes details about a state's underlying market characteristics, divided into three principle categories:

Economic variables include average land value, average power prices, income per capita, and percentage of land classified as developed by the U.S. Bureau of Economic Analysis.

Political variables include the number of regulations and incentives affecting wind and solar development, information about a state's RPS program, and binary variables for policies like renewable energy credits, utility deregulation, and net metering. Other political variables included that do not directly pertain to the renewables industry are right-to-work policies and whether the state government is under Democratic or Republican control, included because of the extent to which developers cited union strength as a barrier to project development.

Environmental variables include the number and density of endangered species, amount and value of protected and federal land, and the number of lawsuits filed in a state under the National Environmental Policy Act between 2000 and 2015.

Section B: Results and analysis

Like previous studies, this analysis finds a strong correlation between a state's resource quality, measured in terms of its total potential output of wind or solar power, and its actual output. The correlation is particularly strong for wind, where resource quality was the only factor that yielded a statistically significant positive correlation with output, measured both in terms of a state's total wind generation (MWh) and number of developed wind projects (Figure 9). Solar generation, including both distributed and utility-scale assets, is also strongly correlated with generating potential, although factors like a state's power prices and total number of solar policies also had statistically significant positive effects at the 5 percent level, while its wind potential had a statistically significant negative effect at the 10 percent level. More surprisingly, this analysis did not yield any statistically significant relationship between a state's proclivity towards environmental litigation and the strength of either its wind or solar industry, measured both in terms of raw number of projects developed and share of total power generation.

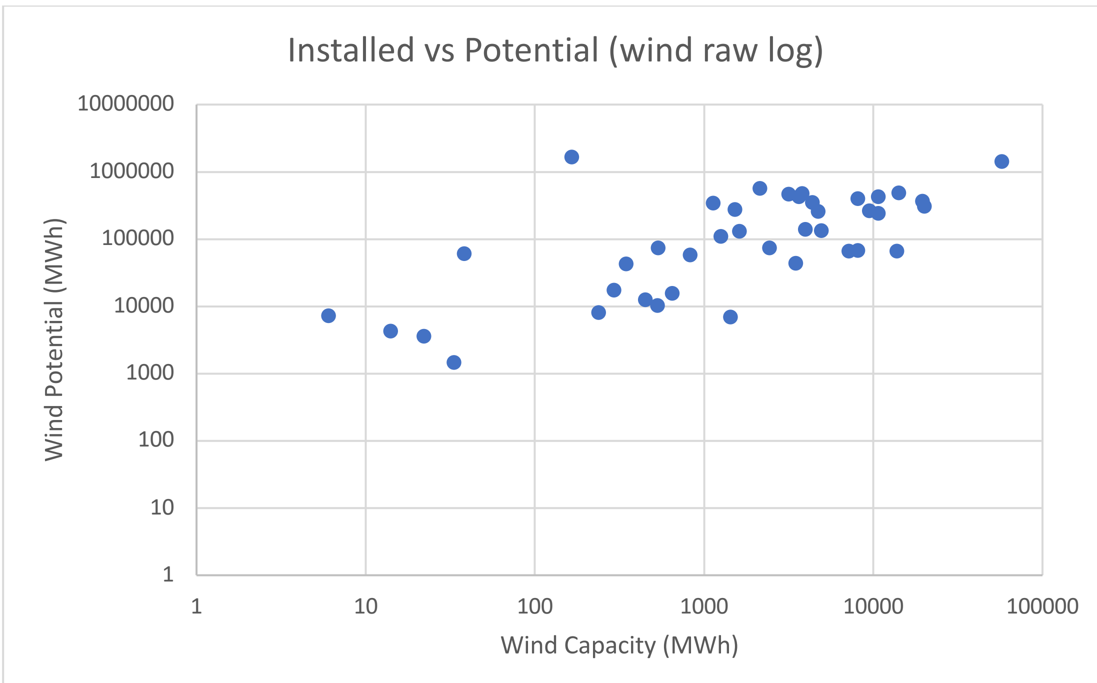

Figure 9

Environmental policy variables

Several developers suggested that the Endangered Species Act is a major impediment to constructing utility-scale distributed projects. According to the preponderance of developers consulted for this project, the effects of the ESA are particularly acute in states with a high percentage of federal land, because any project that requires developing generation or transmission capacity on federal property is subject to litigation under the National Environmental Policy Act. The stipulations established by those two federal laws alone can be so complex that renewables companies often have positions specifically tasked with ensuring that they are complied with: EDF Renewable Energy, for example, employs a Permitting & Environmental Manager and an Environmental Strategy Director for that purpose. Further complicating matters, the Bureau of Land Management and U.S. Fish and Wildlife Services delegate the permitting process to regional branches and offices, which can vary widely in terms of how quickly and reliably they approve projects. The director of origination for one development company with projects nationwide stated that his company tends to avoid working on federal land altogether for that reason, describing the permitting process as challenging and often arbitrary.

It stands to reason, then, that the concentration of endangered species and the percentage of federal land in a given state should negatively influence that state's renewable generating capacity. For instance, Andy Bowman, the former president of Pioneer Green Energy, cited California and Maryland as particularly difficult markets in which to develop wind projects due to their high concentrations of endangered birds and bats. Yet every developer consulted for this project, including Bowman, agreed that the challenges they face maneuvering around the ESA and NEPA have little to do with the presence of endangered species themselves. Instead, the laws are often manipulated by third party litigants out of self-interest.

"Environmental laws often get used for nonenvironmental ends," Monty Humble of Brightman Energy said. Humble further described NEPA and ESA as "content-neutral vehicles for litigation," citing what he described as a particularly egregious example in which the 104-MW Echanis wind project was scuttled by a NEPA suit brought by the Oregon Natural Desert Association.[58] The Echanis project would have required the construction of a transmission line

[58] "Echanis." *Columbia Energy Partners*.

across BLM land, and ONDA claimed that the project's developers had not adequately assessed whether the new infrastructure would impact the ground-dwelling greater sage grouse.[59] In particular, ONDA was concerned that the transmission line would provide "perches for predatory raptors and corvids," as well as create "noise or other project-related disturbances" that could fragment sage grouse habitat.[60] The case made its way up to the U.S. Court of Appeals for the Ninth Circuit, which reversed in part a lower-court decision in favor of the defendants and halted construction on the project. The majority opinion rejected the arguments raised by the plaintiffs in the case, but held that the BLM did not adequately measure a baseline sage grouse population in the affected territory before granting an easement to the developer, Columbia Energy Partners.

Another developer cited labor unions as a frequent impediment to project construction, particularly in California. By threatening NEPA suits against any developer that uses contract labor, unions can extract concessions and demand higher wages on behalf of a project's construction workers and maintenance crews.

This study used the number of NEPA suits brought within a state between 2000 and 2015 to evaluate the effects of endangered species populations, in addition to third parties that exploit the regulations that protect those species, on renewable development. There is a very strong positive correlation between the number of NEPA suits filed within a state and both the number and density of endangered species, as well as the amount of federally protected land, within that state.[61] Furthermore, in line with the developer's hypothesis, there is a statistically significant positive correlation between the political power wielded by labor unions (measured by whether

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[59] *ONDA v. Jewell*, No. 13-36078 (9th Cir. 2016). 2.
[60] *ONDA v. Jewell*. 10.
[61] The *specdensity* variable was calculated by dividing the number of endangered and threatened species in a state by its total acreage. Its statistical significance in Table 1 depends on the exclusion of Alaska and Hawaii from the regression, both of which are extreme outliers in terms of total land area and number of endangered species and for which there is no available data on the value of federal land. The *species* and *righttowork* variables remain statistically significant at the 1 percent level with Alaska and Hawaii included.

the state has adopted right-to-work legislation) in a state and the number of NEPA suits filed therein, as shown in Table 1.[62]

However, in contrast to the developers' suspicions, this study found no statistically significant relationship between the number of NEPA suits filed in a state and the number of wind and solar projects commissioned in that state, as demonstrated in the wind and solar tables below.

Wind

Table 2 presents the results of a multilinear regression model that assessed the impact of various policy mechanisms and power market characteristics on wind development, measured in terms of the percentage of a state's total power generation that comes from wind projects.[63]

Table 3 presents the same variables regressed on the overall number of wind projects in a state. I used both variables to assess whether states with low generating capacities have successfully incentivized smaller projects. Including wind projects as another dependent variable also allows this study to account for the possibility that high-output projects in states with strong wind potential could mask the negative effects of environmental regulations on the industry as a whole. Neither scenario appears in the data, and so Table 3 looks quite similar to Table 2.

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[62] The variables *pctvalfed* and *pctdev* refer to the percentage of a state's total land value owned by the federal government and the percentage of the state's land area classified as developed, respectively.

[63] *Windpotentialmw*: Wind potential (MW), according to the National Renewable Energy Laboratory
Solarpotential: Ranking in NREL's Sun Index
Totalutilgen: Total utility generation (MW)
Windpol: Total number of policies and incentives that apply to wind developers
Rpsnum: Percentage of state's electricity generation that must come from renewable sources by a certain year
Deregulated: Whether the state's electricity market has undergone restructuring (binary variable)
Pctprotecttotal: Percentage of state's land area classified as protected by the state or federal government
Specdensity: Number of endangered species in a state divided by the state's total area (sqmi)
Pcekwh: Average electricity price, ($/kWh)
Valperacre: Average land value ($/acre)
Incpercap: Per-capita income
Sqmi: Area (sqmi)

These results largely correspond to recent industry trends. Wind power is the cheapest source of electricity throughout much of the central U.S., including deeply conservative states with a political aversion to renewable incentives. As a result, states that lag behind the rest of the country in terms of renewable incentives, such as Wyoming, Kansas, and North Dakota, have some of the highest percentages of wind penetration in the country (Figure 10).[64] Conversely, there are very few state-level policy mechanisms or incentives targeted specifically towards wind, and states with such incentives in place often face other barriers to wind development like small land areas and low quantities of available property. The fact that wind is most likely to succeed in the regions that are least likely to help it do so may explain why there is no correlation between a state's political support for wind development and its actual generating output.

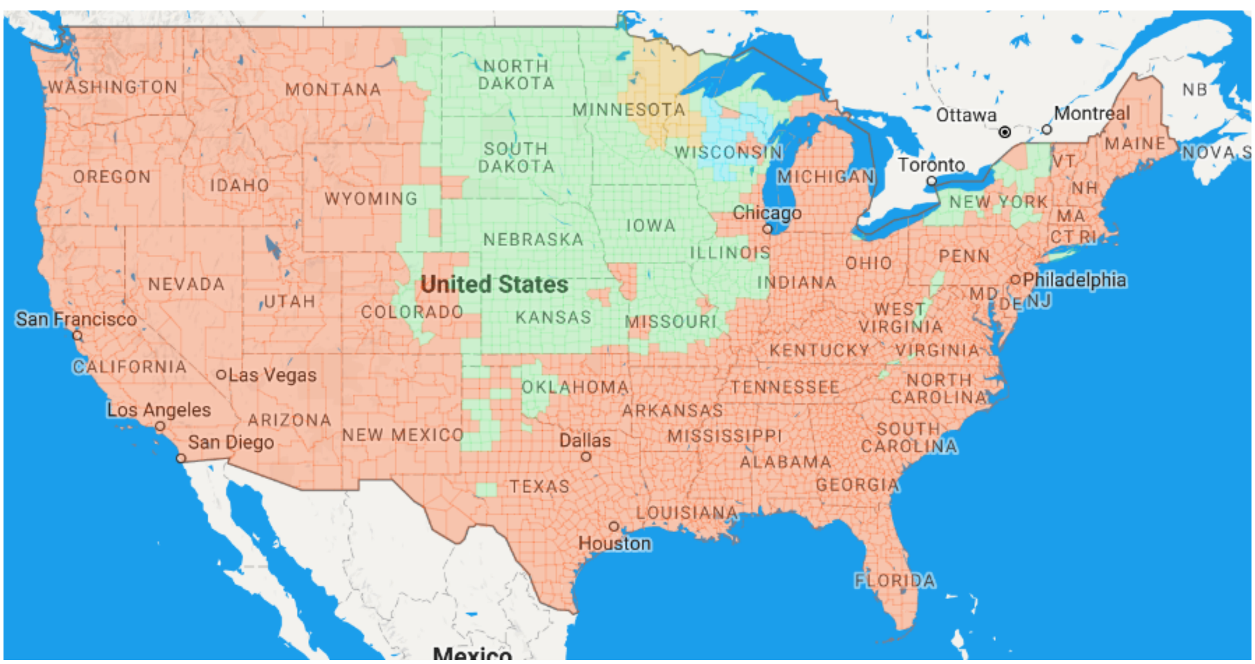

Figure 10: Green represents counties in which wind is the cheapest power generating resource. Red corresponds to natural gas, yellow to subbituminous coal, and blue to nuclear.

[64] Fig. 10 source: Full Cost of Electricity, University of Texas at Austin.

None of the variables that account for endangered species yield a statistically significant relationship with wind development.[65] This result suggests that markets in which wind is price competitive are attractive to developers regardless of the hurdles that the ESA, NEPA, and their state-level equivalents introduce to the construction process. It is also possible that all power generating sources, including power plants, face similar environmental permitting barriers, mitigating the affect that those regulations have on the wind and solar industries. After controlling for other variables, this study also found no relationship between deregulated electricity markets and wind development. This result does not suggest, however, that market design plays no role in the renewable integration process. Chapter 3 discusses the influence of ISO policies on renewable power, with a special focus on ERCOT and CAISO.

Solar

There are more variables that influence a state's total solar generation than there are that influence its wind generation. Some of that disparity stems from the effect of including California, responsible for 47 percent of America's total solar generation and just under 50 percent of its utility-scale solar generation – the gulf between California's solar output and that of every other state is so wide that it can lead to spurious results. For that reason, Table 4 excludes California, as well as the District of Columbia, which imports most of its power from Maryland and Virginia and generates almost none on its own, and Alaska and Hawaii, for which there is no available data on overall land development.[66]

[65] The statistical significance of the *nepa* variable in Table 2 comes from California's outlier status, with nearly twice as many NEPA suits filed as second-place Oregon and more wind installed (MW) than all but three other states. The relationship disappears with California removed from the regression.
[66] Because of its high power prices and lack of easily accessible land, nearly half of the power generated within DC's limits comes from distributed solar resources.

In contrast to the wind analyses above, the cumulative number of solar policies in a state does yield a statistically significant positive relationship (at the 5 percent level) with the percentage of that state's total power generation drawn from solar resources. This analysis also included two binary variables representing types of policies only applicable to utility-scale solar developers: solar permitting, a regulatory barrier which I predicted would have a negative relationship with solar development, and solar renewable energy credits, which I predicted would have a positive relationship with solar development.[67] While the presence of a SREC program positively correlated with *pctgensolar*, the *permitting* variable did not correlate at all with the dependent variable. Deregulated markets negatively correlated with solar development with significance at the 5 percent level, although this result may be influenced by the fact that most deregulated states are in the Northeast, where solar resource quality is weak, or in states with a stronger wind resource than solar like Texas, Oregon, and Illinois. There is some evidence that states with high wind power potential generate lower percentages of their power from solar, with *windpotentialmw* negatively correlating with *pctgensolar* at a 10 percent level of significance.

Furthermore, NEPA suits did not have any adverse impact on a state's solar generation, suggesting that, as with wind, environmental regulations that restrict the development of renewables do not negatively affect a state's output of renewable power. The strongest predictor of solar power's share of a state's power generation, with significance at the 1 percent level, is power prices. In states where electricity is expensive for consumers, solar provides a greater share of the power supply. That largely stems from the fact that the economics of rooftop solar become more favorable as utility bills rise.

[67] For a more comprehensive analysis of SRECs, see p. 46.

Taken together, these results suggest that without incentives, solar photovoltaics are not price-competitive with other forms of power generation in most electricity markets, even those in America's sunnier states. At the same time, the results suggest an opening for solar power in regions with high power prices and a favorable regulatory structure. That may explain why wind potential negatively correlates with solar generation. In a state like Texas or Oklahoma with a strong resource of both solar and wind, the latter will likely attract more interest from developers and investors, since most incentives for renewable power apply to both wind and solar generation. In addition to the price differential between the two technologies, wind may also enjoy an advantage over solar in the form of its greater siting flexibility. Many developers discussed the ease of convincing private landowners to allow wind turbines on their property, since royalty payments are generally high and the propellers do not interfere with agriculture. Solar, for its part, requires a smaller amount of land overall, but cannot collocate with crops or livestock. "It's almost like building a parking lot," Bowman said of utility-scale solar development. States without a viable wind resource, in contrast, may derive value from incentivizing solar, to help businesses and households reduce the costs of their power consumption.

To test whether these variables have a greater effect on utility-scale or distributed solar, I replaced *pctgensolar* with a *solarutilprojects* variable, representing the number of utility-scale solar projects developed by state without considering the installation's size or generating capacity (Table 5).

In this regression, solar potential shows no relationship with the number of projects developed per state, and the most significant variable is the number of solar incentives, with a positive correlation and significance at the 1 percent level. Solar potential showed no significant relationship with the overall number of projects developed, although wind potential still has a slight negative correlation with significance at the 10 percent level. Power price did not correlate with the number of utility-scale projects developed, suggesting that its relationship with overall solar generation in Table 4 stems from its effect on distributed solar. The positive relationship between developed land percentage and solar projects, significant at the 5 percent level, may stem from outliers like California, New Jersey, and North Carolina, but it suggests that similarly urbanized regions can benefit from utility-scale solar development with the right incentives in place.

Other variables of note, both significant at the 10 percent level, are permitting requirements and density of endangered species. *Permitting*, a binary variable representing whether a state has adopted siting and zoning guidelines for solar installations, positively correlates with the number of projects. This may be a result of collinearity with the *solarincent* variable, which encompasses regulatory as well as financial policies, since states with such restrictions in place may be more likely to complement them with beneficial incentives. The negative correlation between endangered species density and project development may suggest that the Endangered Species Act poses barriers to utility-scale solar, or it could be an outgrowth of high species densities in small Northeastern states (Rhode Island, Delaware) and incentive-less Southern states (Alabama, Tennessee) that are not good climates for utility-scale solar to begin with.

Section C: Study limitations

There were a few limitations that restrict the breadth of this study’s conclusion. The absence of county-level data likely influenced the results of the endangered species variables. Species density can vary dramatically within states, and so the problems developers spoke about in states like California and Oregon could have been overlooked in this study by the lack of more granular data. A study evaluating the effect of endangered species density or protected habitat on development by county might affirm the hypothesis that environmental protections can adversely affect renewable integration.

This study also did not evaluate the magnitude of different incentive programs, which could have an influence on development overall. Some states offer more lucrative tax credits than others for production or investment, and cashback programs or tax abatements for commercial and residential procurers can also vary dramatically.

The RPS variable would have been more productive in a study using time-series data, which would help evaluate whether renewable buildout increases after an RPS is put in place. Dividing the NEPA data into its constituent years could also explain whether the prevalence of environmental litigation deters developers from working in a state in the future.

Chapter III: Tomorrow

To what extent will the market characteristics described in Chapter 2 shape the future of the wind and solar industries?

As Chapter 1 described, the U.S. wind industry is relatively nascent, and the solar industry newer still. So while the empirical results of Chapter 2 reveal an interesting snapshot of what factors influence the industry today, it is not clear ipso facto whether they carry any predictive value. This final chapter attempts to address that question with case studies into the market characteristics of some of the more renewable-friendly states, most notably Texas and California. It concludes with a discussion of how future developments beyond the scope of this analysis will affect the industry going forward, with a particular emphasis on federal policy under the Trump administration and the emergence of the energy storage industry.

Section A: Texas

On the regulatory side, Texas has done little to either promote or slow the growth of renewables, with ERCOT and the PUC adopting a laissez-faire ethos that has benefitted wind and will likely do the same for solar as costs continue to decline. Two developers cited SB 277, which would render wind projects ineligible for tax credits if they are built within 30 nautical miles of a U.S. Air Force base, as a potential impediment to construction if it were to pass, but the bill is not currently on the intent calendar after passing through the Committee on Veteran Affairs and Border Security on a 4-3 vote.[68]

There are two main reasons that this hands-off approach has helped spur the development of the renewables industry in Texas. The first is its geographic blessings: Texas has the sixth-best solar resource and second-best wind resource (trailing only Alaska) in the country, coupled with almost no endangered species or federal land to interfere with project development. The lack of

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[68] SB 277, 85th Texas State Legislature. 2017.

government-owned property is particularly impactful in the wind industry, where projects are often constructed without the developer purchasing any land at all, instead offering leasing fees and royalty payments to landowners in exchange for the right to construct turbines on their property. This process is often quite lucrative for landowners: in 2016, cotton farmer Rolan Petty told the *MIT Technology Review* that he earns $7,500 annually on each of the several turbines installed on his estate. And it spares wind developers, whose projects often require dozens of square miles of territory, the high upfront cost of purchasing that land outright. This arrangement, however, is only possible on private land, since the permitting process for developing federal property is both arduously long and easy to litigate.[69]

The second structural advantage that the Texas power market presents to renewable developers is its exemption from FERC oversight. As the only state in the country with its own independent power grid, separate from both the Eastern and Western Interconnections, the ERCOT market largely operates under its own set of regulations, with frequent input from a Board of Directors and various advisory committees comprised of industry stakeholders.[70] That degree of independence gives the Public Utilities Commission of Texas an outsized role in setting the state's energy policy. Meanwhile, the direct interactivity among policymakers and the private sector that ERCOT provides allows the state to move relatively quickly on designing a marketplace that suits the state's political vision. In tandem, these factors provided the state with tremendous leeway to facilitate wind development once it became clear that wind energy was price-competitive with conventional generating resources, and particularly after the scorching

[69] Groom, Nichola. "U.S. Seeks to speed wind, solar development on federal lands." *Reuters*, 10 November 2016.
[70] "Committees and Groups." Electric Reliability Council of Texas.

summer and frigid winter of 2011 caused rolling blackouts across the state due largely to a shortage of natural gas.[71]

The Texas wind boom began in earnest in 2005, when the state first announced plans to develop a $7 billion network of high-voltage power lines that would directly transfer electrons from the windy regions of West Texas to load centers in the rest of the state. At the time, natural gas in Texas cost $7.62 per thousand cubic feet, and the state was angling to meet an RPS that called for 5,000 MW of renewable generation by 2015. In the years between the project's commencement and its completion in 2013, the capital costs of wind declined, and investors saw wind power as a hedge against the possibility of price volatility in the natural gas market. By the time the 18,500 MW Competitive Renewable Energy Zone (CREZ) lines joined the grid, ERCOT operators were reviewing 21,000 MW worth of projects.[72]

The strain that Texas's installed wind capacity has placed upon the power grid may raise the cost of future wind projects, which will not be able to regularly transmit the electricity they generate from their rural node points to the load centers that comprise most of the state's power demand. That has created an opportunity for utility-scale solar in the state, particularly as its input and installation costs continue to decline. Although West Texas has a much stronger solar resource than East Texas, at least two major developers are exploring the possibility of developing sites in the latter, where transmission costs are lower and there is no need to compete with wind developers over access to power lines. Texas's installed utility-scale solar capacity has already nearly doubled in recent years, jumping from 288 MW to 556 MW from 2015 to 2016, and ERCOT projects that number to increase to 2,575 MW by 2020, based exclusively on

[71] Galbraith, Kate. "The Rolling Chain of Events Behind Texas Blackouts." *Texas Tribune*, 3 Feb 2011.
[72] Malewitz, Jim. "$7 Billion New Wind Power Project Nears Finish." *Texas Tribune*, 14 October 2013.

contracts that have already been signed.[73] Looking ahead, ERCOT projects solar to account for nearly all capacity additions to the grid over the next 15 years.[74]

Whether that scenario leads to power price volatility and supply intermittency is unclear. A number of public officials and grid experts in the state who offered their assessments under the condition of anonymity suggested that because solar and wind are naturally complementary, with wind generating more power at night and during the winter, grid operators should be able to manage some degree of variability in the power supply. A window around 7 p.m., when solar will go offline but wind production will not yet have peaked, could pose issues if the state's baseload natural gas production declines. However, Texas's wind and solar capacity installments are both so new that there have been no studies into how seasonal variability and long-range weather patterns like El Niño would affect power generation.

Section B: California

In keeping with its reputation as one of America's more environmentally conscious states, California has a long record of offering public support for renewable energy. The state has had an aggressive RPS in place since 2002, as well as more policies affecting the solar and wind industries than any other state. It also has a history of bad air pollution, which previous studies on energy policy have suggested correlates with a state's affinity for renewables-friendly policies.[75] Correspondingly, California generated more wind energy than all but four other states in 2016. And its 580,752 solar projects generated 25,011 MWh of energy that same year, more than quintupling the output of second-placed Arizona.[76] Going forward, the state plans to accelerate its public support for renewables even further: In February, State Senate Majority

[73] Ragsdale, Kenneth. "ERCOT Overview and Integration of Renewables." *ERCOT*, 8 February 2017.
[74] Borkar, Sandeep, et al. "2016 Long-Term System Assessment for the ERCOT Region." *ERCOT*, December 2016.
[75] Carley, 2009.
[76] California Solar Statistics.

Leader Kevin de Leon (D-Los Angeles) introduced an updated RPS that would require California to procure 100 percent of its power from renewables by 2045.[77] Because of the logistical challenges of wind development California, coupled with its strong solar resource, most of that new generating capacity will come in the form of solar. That transition is already underway, as wind development has tapered off as solar development has accelerated in California over the past few years (Figures 11 and 12).[78]

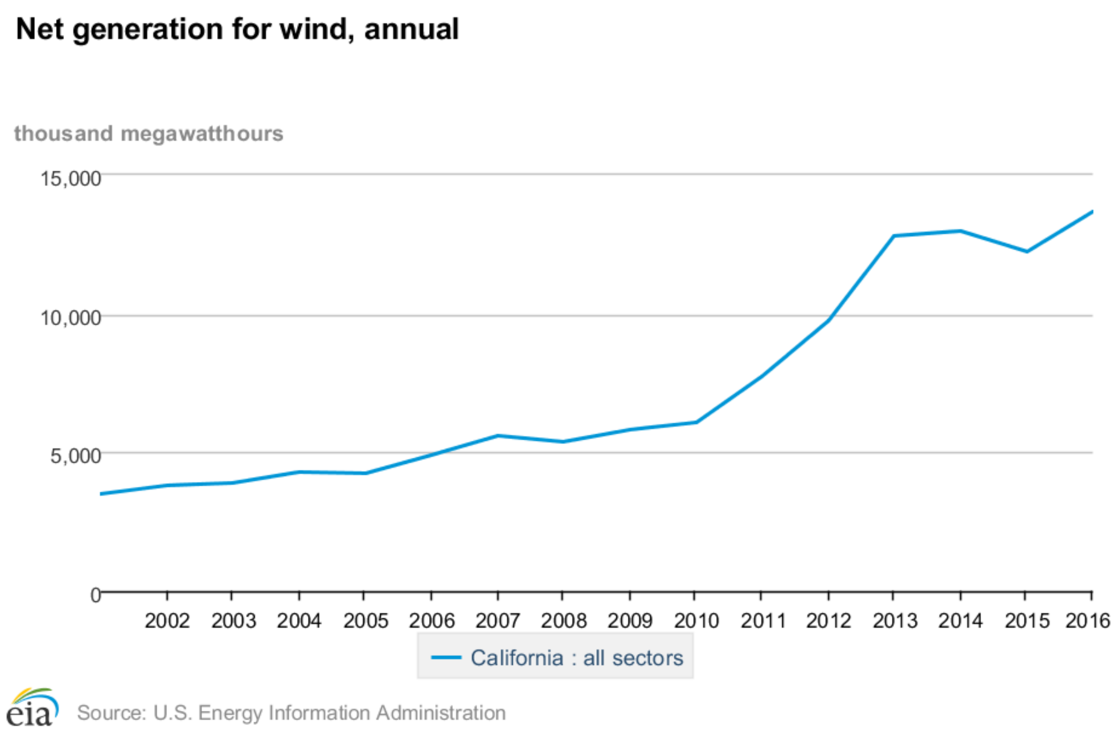

Figure 11

[77] SB 584, California Legislature – 2017-18 Regular Session. "California Renewable Portfolio Standards Program."
[78] Figures 10 and 11 source: Electricity Data Browser, U.S. Energy Information Administration.

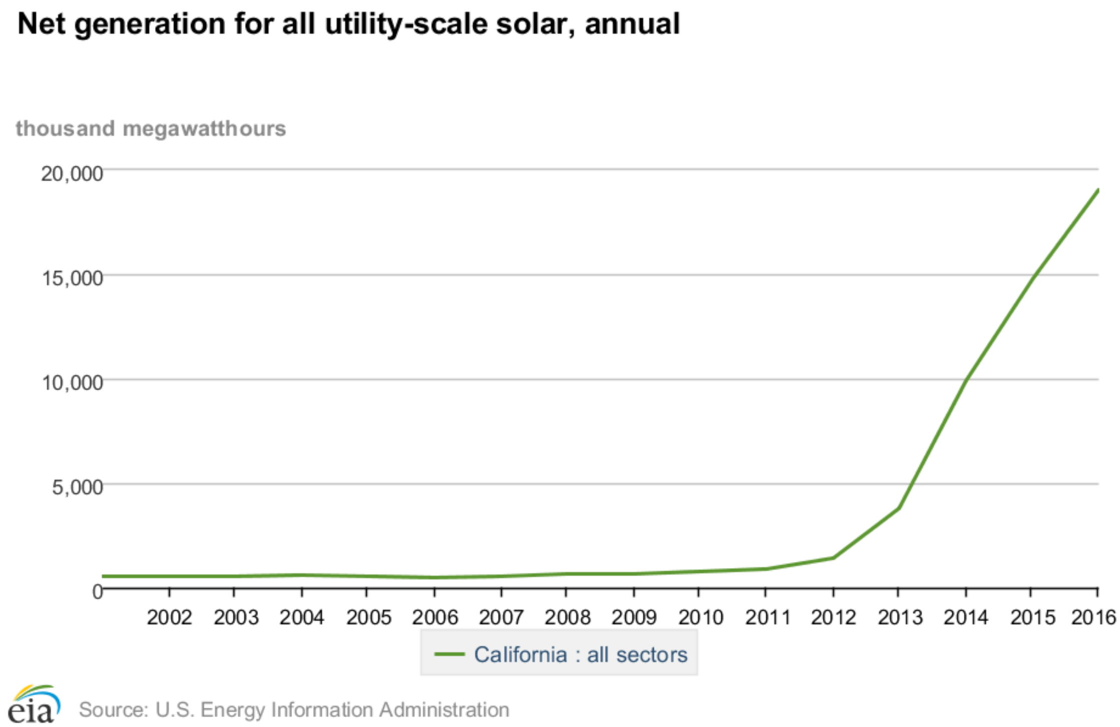

Figure 12

But whether the state can maintain a reliable and affordable power grid in light of its aggressive approach towards renewable development remains a matter of debate. In his keynote address at the American Council on Renewable Energy's annual policy forum, Michael Picker, the president of the California Public Utilities Commission, spoke of California's need to transition into a "post-renewables future" and stated his opposition to the proposed RPS update.[79]

As discussed briefly in Chapter 1, California's electric grid has already faced two interconnected logistical challenges, one logistical and one financial, pertaining to its increasing integration of solar energy. The root of the problem is that while solar energy is abundant in the middle of the day, the generating capacity of solar installations declines rapidly in the early

[79] Picker, Michael. "Keynote Address." ACORE Policy Forum, Washington, DC. March 16, 2017.

evening. Further complicating matters, solar energy is cheap enough during its peak hours -- particularly with subsidies as extensive as California's -- that grid operators need to turn off coal and natural gas plants to prevent overgeneration. That means that those same coal and gas plants must come back online quickly in the early evening (refer to Figure 8 in Chapter 1 for a visual representation of this phenomenon), which is part of why California has higher power prices than any state within the continental U.S. outside of New England. For the solar industry, the financial consequence of this variability is that the marginal value of solar power declines quickly as solar capacity increases, which will make solar projects progressively more expensive to develop in markets that already have a high level of solar integration.[80] [81] In fact, without advancements in energy storage technology, further solar development in California might become economically unviable altogether.[82] According to an NREL study on California's solar market, "as curtailment increases, the benefits of additional PV may drop to the point where additional installations are not worth the cost, creating an economic limit to deployment."[83]

These emerging limitations to solar integration in California are exacerbated by the state's difficult development process. While the state's nation-leading number of NEPA lawsuits has not diminished its cumulative solar development to date, as demonstrated by the regressions in Chapter 2, California still requires developers to submit a full environmental impact assessment under a provision of the California Environmental Quality Act (CEQuA), One developer described this process as "very expensive and time-consuming," largely because it

[80] Mills, Andrew and Ryan Wiser. "Changes in the Economic Value of Generation at High Penetration Levels: A Pilot Case Study of California." Environmental Energy Technologies Division, Ernest Orlando Lawrence Berkeley National Laboratory. June 2012.
[81] Sivaram, Varun and Shayle Kann. "Solar power needs a more ambitious cost target." *Nature Energy*, Vol. 1, April 2016.
[82] For more information about the relationship between energy storage and renewable deployment, see p. __
[83] Denholm, Paul and Robert Margolis. "Energy Storage Requirements for Achieving 50% Solar Photovoltaic Energy Penetration in California." National Renewable Energy Laboratory, August 2016.

requires public hearings that can gin up orthogonal complaints about the development process. And because there are already 460 utility-scale solar installations in California, more than in any other state, most of the most promising sites have already been developed, with the remaining sites rendered less attractive to investors due to some combination of a lower resource quality and more expensive land. As a result, not only does each solar installation diminish the value of the energy produced by every other solar panel on the grid, but it also raises the initial cost of each subsequent solar installation after controlling for technological improvements.

A few of the developers I consulted also took issue with CAISO's management of California's power sector, with one describing the organization as "punitive" and another using the term "laughable." For instance, unlike ERCOT, CAISO requires developers to pay for the right to interconnection into the state's transmission system when a project first begins construction, rather than at the point of completion. This pricing mechanism has proved challenging for renewable developers, since projects in California can take longer to complete than those in other states because of the environmental impact standards set by CEQuA. And since California has not invested in a publicly funded transmission buildout like the Texas CREZ lines beyond incremental improvements to the 3220 MW Pacific DC Intertie, some developers worry about the prospect of being required to pay to upgrade the lines on which they transmit the power they generate.[84] "It's like a guillotine at the end of the process," Andy Bowman said. He estimated that transmission upgrade payments can cost a developer between \$10 million and \$100 million.

Part of why the CAISO market poses such a challenge for developers is that the deregulation of California power sector initially yielded disastrous consequences for the state,

[84] Heutte, Fred. "Conceptual Solution for Consideration: Pacific DC Intertie Upgrade." *California Independent System Operator*, 23 February 2016.

with price fluctuations and rolling blackouts costing consumers $40 billion in added energy costs from 2000 through 2002.[85] California began the deregulating process in 1996, when it opened its power markets to merchant generators independent of its three main electric utilities.[86] However, by 2000, weather-related increases in peak demand and decreases in hydropower generation, combined with "regulatory uncertainty" and an underdeveloped power market that relied heavily on spot trading, caused pervasive and repeated problems with undersupply.[87] In response to these market failures, the state placed limitations on retail choice while still allowing merchant generators to sign bilateral contracts to directly supply power to particular utilities.[88] In recent years, that unorthodox model of partial deregulation has hamstrung its utilities' ability to accommodate distributed resources, according to Picker.[89] Furthermore, the crisis sowed an environment of distrust among the Public Utilities Commission, state legislature, and CAISO that "fragmented" California's regulatory regime, leading to "overlaps and conflict" among various stakeholders.[90] This political chaos has turned a number of developers and financiers away from the California market. One former commodity trader described a number of instances in which state regulators would retroactively impose a new rule onto a preexisting generating asset, leading his firm to look elsewhere for investment opportunities.

Between its underdeveloped transmission infrastructure and flawed power markets, California still faces limits on how much value it can extract from its public investments in solar power, even as its strong RPS standards and incentive programs helped the state's solar industry

[85] Weare, Christopher. "The California Electricity Crisis: Causes and Policy Options." *Public Policy Institute of California*, 2003. 3.
[86] Weare 11.
[87] Weare 15-38.
[88] Lacey, Stepben. "Is Retail Electricity Choice Coming to California?" *The Energy Gang.* Podcast audio, 1 March 2017.
[89] Ibid.
[90] Weare 3.

emerge from nascence. To address the problem, CAISO has advocated for the creation of an interstate energy imbalance market, which would allow for energy trading across state lines within the Western Interconnection region. That would allow California to offload some of its solar power to neighboring states rather than curtail it during the day, while importing wind and coal power from those same states at night. There are clear economic benefits to such partnerships. A study conducted by the consultancy Energy + Environmental Economics and commissioned by CAISO found that ratepayers would save between $1.8 billion and $6.8 billion between 2015 and 2024 as a result of PacifiCorp, which manages generating assets in Oregon and Utah, merging into California's power market in April 2015.[91] However, no other companies or states have followed suits, and Picker does not expect any upcoming changes to the status quo due to the importance of in-state power generation to coal-dominant Rocky Mountain states. "Elected public utility commissioners in states like Montana, Utah, and Wyoming will not let California electrons into their markets," Picker said in his address at ACORE.[92] "They would be replaced overnight."

Section C: Other notable states

While Texas and California are the two most developed markets for wind and solar power in the U.S., other states have adopted innovative programs that provide useful case studies into how market and policy mechanisms can affect renewable deployment.

New Jersey

Amazingly, there are over three times as many utility-scale solar projects in New Jersey as there are in Arizona, despite the latter's abundant sunshine and relatively inexpensive land prices. That strange statistic stems from New Jersey's solar renewable energy credit (SREC)

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[91] "Regional Coordination in the West: Benefits of PacifiCorp and California ISO Integration.' California Independent System Operator, October 2015.

[92] Picker

market, which it established to create a financial incentive for solar generation. The owners of rooftop and utility-scale solar projects earn one SREC for each kilowatt of solar energy they generate, and the state determines the value of the instrument at annual auctions.[93] In its first few years of operation, SREC values stayed above $600 per kilowatt, which allowed utility-scale solar installations to compete in New Jersey's deregulated wholesale market. However, the market began to slow down around 2011, and the credit's volatile value made long-term investments a challenge, according to Bowman.[94] The rise and fall of New Jersey's utility-scale solar market suggests that, in line with this study's empirical analysis of cumulative solar project development, there is a causal relationship between how lucratively a state incentivizes solar generation and how many projects are built in that state.

New York

New York has taken the opposite approach to incentivizing solar power, with a heavy focus on distributed generation. In 2014, Governor Andrew Cuomo launched a comprehensive State Energy Plan to complement New York's RPS, which calls for 50 percent renewable generation by 2030. In addition to the state's Clean Energy Fund and New York Green Bank, which are designed to attract private capital into financing large-scale renewable generation, the state has invested over $1 billion in solar energy, with an emphasis on facilitating solar development in schools and small communities.[95] That initiative contributed to a 575 percent increase in New York's solar generating capacity between 2012 and 2015. To date, over 83.5 percent of the state's solar power output comes from distributed resources.[96]

[93] Bolman, Chris, et al. "End of the Gold Rush: Crash of the U.S. SREC Markets?" Photon Consulting, 2014.
[94] "SREC Pricing." New Jersey Clean Energy Program.
[95] "Reforming the Energy Vision." State of New York.
[96] U.S. Energy Information Administration.

To prevent that outgrowth of rooftop and community solar from creating the same logistical challenges that California's grid is currently facing, New York has proposed a unique compensation model for its regulated electric utilities, which would require them to provide distributed system platform (DSP) services to distributed generators in exchange for new incentives in the "ratemaking paradigm."[97] Essentially, the program would help utility companies like Consolidated Edison (ConEd) transition from transmitting and distributing power themselves to providing operational services on behalf of a decentralized grid in a role similar to that of an air traffic controller.[98] At the heart of this project is the Brooklyn/Queens Demand Management Program (BQDM), under which ConEd will provide an anticipated 22 MW increase in summer peak demand in 2017 and 2018 entirely via demand response and energy efficiency initiatives.[99] If successful, BQDM would replace a proposed $1 billion substation that the two boroughs would otherwise need to satisfy peak demand.[100] More broadly, the program could serve as a model for how similarly urbanized states can leverage distributed solar generation into an affordable and reliable asset.

Section D: Looking ahead

Storage

Every developer, financier, and regulator I consulted for this project cited battery storage as the single factor most likely to fundamentally transform the power sector. By balancing the intermittency of solar and wind power, battery storage would prevent problems with oversupply and curtailment like those plaguing California, as well as the challenges with congestion that

[97] "Staff White Paper on Ratemaking and Utility Business Models." Case 14-M-0101, State of New York Department of Public Service. 28 July 2015. 7.
[98] Bade, Gavin. "REV in 2016: The year that could transform utility business models in New York." *Utility Dive.* 20 January 2016.
[99] Tweed, Katharine. "Con Edison Unveils Auction Numbers for Its Pioneering Demand Management Program in New York." *Greentech Media*. 5 August 2016.
[100] "Reforming the Energy Vision." State of New York. 9.

Texas has faced in the CREZ regions. Within a distributed framework, battery storage would allow commercial and residential solar producers to store their excess power rather than selling it back to the transmission and distribution provider, enabling them to disconnect from the grid altogether.

Whether either of these scenarios will be viable in the near or intermediate future is unclear. In November 2016, the first two large utility-scale lithium-ion batteries went online in California, when Pacific Gas and Electric's 2 MW Vaca-Dixon and 4 MW Yerba Buena systems began providing ancillary services within the CAISO market.[101] After a 2016 methane leak from the Aliso Canyon natural gas storage plant in California raised concerns of rolling blackouts in the state, other utilities in Southern California followed suit, and there are now over 1,800 MW of battery storage projects nationwide that should come online by 2021.[102] However, with such a small installed capacity, it is difficult to evaluate how these utility-scale battery installations will affect power markets going forward.

The economic viability of distributed battery storage largely depends on the strength of a state's net metering policies for rooftop solar owners. A study from the Rocky Mountain Institute found that solar and storage systems are already competitive in Hawaii, where power prices are higher than in any other state due to the exorbitant costs of importing fossil fuels, and will soon reach that point in New York and California.[103] However, a follow-up study found that "the financial case for grid defection in the U.S. is limited or nonexistent given current costs and policies," with revisions to net metering policies in Hawaii and California providing a lower-cost

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[101] "PG&E Battery Storage Systems are First to Successfully Participate in California Electricity Markets." *Pacific Gas and Electric.* 10 November 2016.
[102] Cusick, Daniel. "Battery Storage Poised to Expand Rapidly." *Scientific American,* 1 January 2017.
[103] Bronski, Peter, et al. "The Economics of Grid Defection: When and Where Distributed Solar Generation Plus Storage Competes with Traditional Utility Service." *Rocky Mountain Institute.* February 2014.

alternative to solar and storage systems in the technology's two most promising locations.[104] Further complicating matters, the inefficiencies of battery storage can increase household energy consumption, meaning that "home energy storage would not automatically reduce emissions or energy consumption unless it directly enables renewable energy."[105]

Federal policy

Because federal incentives for renewable development apply evenly across states, they are not conducive to comparing policy regimes or market characteristics at the state level. But they still play a large role in influencing the affordability of renewable power.[106] One financier who assisted with this project said that without the federal investment tax credit, wind power would be nearly impossible to construct anywhere in the country. As a result, President Donald Trump's overtures in favor of reviving the coal industry sent shockwaves through the industry in the aftermath of his election, with most major renewable developers seeing their stock prices fall even as the rest of the market rose in the days after the November 2016 election.[107] However, most industry experts do not foresee federal intervention slowing the development of renewables over the next few years. Ethan Zindler, the head of policy analysis at Bloomberg New Energy Finance, said at the ACORE Policy Forum that while Trump's proposed federal budget "used a hatchet, not a scalpel" in its approach to cutting energy subsidies, the wind and solar industries should see few short-run consequences because most power contracts are signed so far in advance.[108] In the long run, Zindler warned that cuts to the Department of Energy's research and

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[104] Hittinger, Eric and Jawad Siddiqui. "The challenging economics of U.S. residential grid defection." *Utilities Policy,* Vol. 45. April 2017.
[105] Fares, Robert and Michael Webber. "The impacts of storing solar energy in the home to reduce reliance on the utility." *Nature Energy*, Vol. 2. 2017.
[106] "Lazard's Levelized Cost of Energy Analysis, Version 10.0." *Lazard*, December 2016.
[107] Doyle, Alister and Meredith Davis. "Trump win boosts coal, hits renewable stocks." *Reuters.* 9 November 2016.
[108] Zindler, Ethan. "Renewable Energy Outlook: A Major Driver for Power Generation, Economic Growth, and Competitiveness." ACORE Policy Forum, Washington, DC. March 16, 2017.

development budget, including the Advanced Research Projects Agency-Energy (ARPA-E), could damage the industry by restricting the emergence of new renewable energy technologies. However, those consequences would have little impact on the deployment of current wind and solar technologies and thus fall beyond the scope of this analysis.

Section E: Conclusion

The beginning of Chapter 1 alludes to an interesting incongruity in America's power markets: if resource quality and political support are the most important factors driving the development of renewables, why is it that New Jersey has over three times as many utility-scale solar projects as Arizona? Or that Oklahoma generates more wind power than California? Chapter 2 sought to answer those questions by evaluating what combination of political incentives, market characteristics, environmental regulations, and geographic variables correlate with a state's renewable energy generating capacity. The analysis revealed that while wind production strongly corresponds to wind potential, meaning that the windiest states produce the most wind, solar production can vary widely based on the strength of a state's incentive regime, in addition to factors like resource quality and the availability of competing resources.

Chapter 3 took a deeper look into a few particularly notable power markets to evaluate whether any particular programs or structures that help the renewables market in some states can be adopted in other states as well. It concluded that besides deregulating power markets to provide utilities with access to more flexible sources of power generation, the only way for a state to reliably boost solar generation through policy mechanisms is to subsidize production far above market value, as New Jersey did through its ill-fated SREC program. ISOs, for their part, can design market rules and mechanisms intended to spur renewable development, but are subject to federal oversight outside of Texas and, according to a few of the renewable developers consulted for this project, often beholden to the interests of local fossil fuel developers.

The takeaway for policymakers is that, particularly in the solar industry, the effectiveness of state incentives depends on both the state's immutable market characteristics and broader regulatory structures as much as it does on the lucrativeness of those incentives. Conversely, states with little interest in accommodating renewables onto their grids may be forced to do so by market forces pushing the costs of solar and wind power downward. Every day that the sun still shines and the wind still blows, the question of how much states must spend to incentivize renewable development gets easier to answer. Whether or not state governments are paying attention is another question altogether.

Appendix I: Regression tables

The Effect of Environmental and Political Variables on NEPA Lawsuits (2000-2015)

Source	SS	df	MS
Model	114630.794	6	19105.1323
Residual	28998.0223	42	690.429101
Total	143628.816	48	2992.26701

Number of obs	=	49
F(6, 42)	=	27.67
Prob > F	=	0.0000
R-squared	=	0.7981
Adj R-squared	=	0.7693
Root MSE	=	26.276

nepa	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
pctfed	108.1363	45.62609	2.37	0.022	16.05914	200.2135
pctvalfed	-44.25782	66.62672	-0.66	0.510	-178.716	90.20035
species	.6415643	.099925	6.42	0.000	.4399074	.8432211
specdensity	5260440	1731559	3.04	0.004	1766012	8754867
pctdev	-106.7103	91.34453	-1.17	0.249	-291.0511	77.63039
righttowork	-33.52397	8.445506	-3.97	0.000	-50.5677	-16.48025
_cons	9.963275	12.78389	0.78	0.440	-15.83567	35.76222

Table 1

The Effect of Environmental, Political, and Economic Variables on Wind Generation (percentage of total power generation)

Source	SS	df	MS
Model	.237686662	13	.018283589
Residual	.166599708	34	.004899991
Total	.40428637	47	.008601838

Number of obs	=	48
F(13, 34)	=	3.73
Prob > F	=	0.0010
R-squared	=	0.5879
Adj R-squared	=	0.4304
Root MSE	=	.07

pctgenwind	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
windpotenti~w	4.60e-07	1.65e-07	2.78	0.009	1.24e-07	7.97e-07
solarpotent~l	.147935	.1491557	0.99	0.328	-.1551859	.4510559
totalutilgen	-3.08e-07	2.48e-07	-1.24	0.223	-8.11e-07	1.96e-07
windpol	.0006869	.0023586	0.29	0.773	-.0041062	.0054801
rpsnum	.0971734	.1064019	0.91	0.368	-.1190612	.3134081
deregulated	-.0230103	.034617	-0.66	0.511	-.0933607	.04734
pctprotectt~l	.0193117	.1126702	0.17	0.865	-.2096617	.2482852
specdensity	-6497.242	9600.901	-0.68	0.503	-26008.62	13014.14
nepa	.0009693	.0004369	2.22	0.033	.0000814	.0018571
pcekwh	-1.002335	.8001062	-1.25	0.219	-2.628346	.6236764
valperacre	-.0003359	.0005055	-0.66	0.511	-.0013632	.0006913
incpercap	1.93e-06	2.44e-06	0.79	0.436	-3.04e-06	6.89e-06
sqmi	-2.01e-06	1.26e-06	-1.60	0.118	-4.56e-06	5.39e-07
_cons	-.0039843	.1505889	-0.03	0.979	-.3100177	.302049

Table 2

The Effect of Environmental, Political, and Economic Variables on Wind Development (number of projects)

Source	SS	df	MS			
				Number of obs	=	48
				F(13, 34)	=	5.10
Model	26845.8047	13	2065.0619	Prob > F	=	0.0001
Residual	13764.1745	34	404.82866	R-squared	=	0.6611
				Adj R-squared	=	0.5315
Total	40609.9792	47	864.04211	Root MSE	=	20.12

windprojects	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
windpotentialmw	.0001413	.0000476	2.97	0.005	.0000446	.0002379
solarpotential	24.70178	42.87241	0.58	0.568	-62.42543	111.829
totalutilgen	.0000973	.0000712	1.37	0.181	-.0000475	.000242
windpol	.8981518	.6779292	1.32	0.194	-.4795661	2.27587
rpsnum	-10.39663	30.58351	-0.34	0.736	-72.54979	51.75654
deregulated	2.352842	9.950112	0.24	0.814	-17.86822	22.5739
pctprotecttotal	15.12089	32.38524	0.47	0.644	-50.69384	80.93562
specdensity	-967485.2	2759624	-0.35	0.728	-6575717	4640746
nepa	.4048129	.1255797	3.22	0.003	.1496042	.6600216
pcekwh	-18.24088	229.9776	-0.08	0.937	-485.6116	449.1299
valperacre	-.0893564	.1452921	-0.62	0.543	-.3846254	.2059126
incpercap	.0003257	.0007025	0.46	0.646	-.0011021	.0017534
sqmi	-.0006169	.0003609	-1.71	0.096	-.0013503	.0001165
_cons	-29.90294	43.28434	-0.69	0.494	-117.8673	58.06143

Table 4

The Effect of Environmental, Political, and Economic Variables on Solar Generation (percentage of total power generation)

Source	SS	df	MS
Model	.008274861	9	.000919429
Residual	.007630758	37	.000206237
Total	.015905619	46	.000345774

Number of obs	=	47
F(9, 37)	=	4.46
Prob > F	=	0.0005
R-squared	=	0.5202
Adj R-squared	=	0.4036
Root MSE	=	.01436

pctgensolar	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
solarpotential	.0538161	.0249784	2.15	0.038	.0032049	.1044272
windpotentialmw	-2.31e-08	1.16e-08	-1.99	0.054	-4.66e-08	3.73e-10
solarincent	.0006491	.0003174	2.05	0.048	6.04e-06	.0012921
pcekwh	.4050765	.1264334	3.20	0.003	.1488982	.6612548
pctdev	-.0818753	.055497	-1.48	0.149	-.1943229	.0305722
permitting	.0005956	.0051257	0.12	0.908	-.0097901	.0109812
srec	.0191424	.0088927	2.15	0.038	.0011241	.0371608
deregulated	-.0168798	.0076537	-2.21	0.034	-.0323876	-.001372
nepa	-.0000481	.0001219	-0.39	0.695	-.0002952	.0001989
_cons	-.075161	.024685	-3.04	0.004	-.1251775	-.0251445

Table 4

The Effect of Environmental, Political, and Economic Variables on Solar Development (number of utility-scale projects)

Source	SS	df	MS
Model	269381.074	9	29931.2304
Residual	227702.905	38	5992.18171
Total	497083.979	47	10576.2549

Number of obs	=	48
F(9, 38)	=	5.00
Prob > F	=	0.0002
R-squared	=	0.5419
Adj R-squared	=	0.4334
Root MSE	=	77.409

solarutilpr~s	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
solarpotent~l	143.7323	133.8918	1.07	0.290	-127.3174	414.782
windpotenti~w	-.0001029	.0000552	-1.86	0.070	-.0002147	8.93e-06
solarincent	3.967121	1.036214	3.83	0.000	1.869416	6.064826
pcekwh	389.0008	659.4011	0.59	0.559	-945.887	1723.889
pctdev	1010.179	375.7735	2.69	0.011	249.4652	1770.893
permitting	51.37173	27.72891	1.85	0.072	-4.762509	107.506
srec	-40.97767	52.99053	-0.77	0.444	-148.2514	66.29605
deregulated	-56.71866	41.46026	-1.37	0.179	-140.6506	27.21324
specdensity	-2.30e+07	1.14e+07	-2.02	0.051	-4.62e+07	84075.52
_cons	-224.7783	121.5143	-1.85	0.072	-470.7712	21.21454

Table 5

Appendix II: Database Citations

"Electric Power Monthly." *U.S. Energy Information Administration*. February 2017. Table 1.14.B. Utility Scale Facility Net Generation from Wind. 25 April 2017.

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About the Author

Jordan Shenhar, a native of Westport, Connecticut, will graduate in May 2017 with a Bachelor of Arts in Plan II, Economics, and Government, with minors in History and Middle East Studies. He developed an interest in renewable energy while recovering from dengue fever in Costa Rica, where his doctor explained that high surcharges on power generation and poorly designed energy markets drove the cost of electricity up far higher than necessary. Before writing his senior thesis, Jordan interned at the American Council on Renewable Energy, where he conducted research projects on the cost of meeting U.S. emission reduction obligations under the Paris Agreement and on investment opportunities in the geothermal sector. Jordan also authored the energy policy agenda for the U.S. House Future Caucus as a policy intern with the Millennial Action Project in Washington, DC, and has spent five semesters working in the opinion department at *The Daily Texan*. Upon graduation, Jordan will work in renewable energy finance, with an emphasis on infrastructural development. In the long run, he hopes to pursue a career in energy policy.